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DRES

SUFFIELD MEMORANDUM

NO. 1111

PROPOSED IMPLEMENTATION OF A COMPUTER AIDED DESIGN AND DRAFTING (CAD/D) CAPABILITY AT DRES (U)

by

S.G. Penzes

PCN 21V20

September 1985

DEFENCE RESEARCH ESTABLISHMENT SUFFIELD, RALSTON, ALBERTA

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ABSTRACT

The feasibility of installing a CAD/D system at DRES is investigated with the constraints that the recommended system cost less than $150K (1982) and be a "turnkey" installation. The ANVIL 4000L software package, compatible with the recently acquired central computer, a Honeywell DPS8/70C, is recommended.

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1. INTRODUCTION

With the advances being made in the use of computers as an integral portion of the scientific and engineering design process, the implementation of a computer aided drafting and design (CAD/D) system at an establishment such as the Defence Research Establishment Suffield (DRES) warrants serious consideration. It is the intent of this document to provide recommendations to aid in the determination of DRES policy regarding CAD/D.

2. BACKGROUND

The task to investigate CAD/D at DRES was initiated on December 6, 1982. The initial funding contraints of the task dictated that any system to be considered for purchase must cost less than $150K in the first year. In addition, only minimal amounts of time are available from the computer group to provide software modifications and therefore any system considered for purchase should ideally be "turnkey".

3. CAD/D ISSUES

Consideration of CAD/D in an inexperienced environment such as currently exists at DRES, automatically dictates that the issues involved in CAD/D be discussed.

3.1 Potential Benefits

The quality of the products produced by DRES (be they drawings, design, and/or analyses) would see substantial improvement. More alternatives can more readily be considered in the design process. In addition, the refinement and degree of sophistication of these products would be improved.

The speed at which these products could be finished would be improved. When using CAD/D, product quality suffers little degradation as project time spans shorten.

For scientific purposes the ability to easily modify and analyze many alternatives in the design process is invaluable. In addition, when a given project requires design input from multiple sources, the correlation facilities provided by a CAD/D system's integrated data base simplifies component integration.

CAD/D is simply a tool and as such provides only manpower augmentation not replacement. This is true through all levels of a project from the evaluation of alternatives to detailed analysis of a given alternative to the documentation of a final design.

3.2 CAD/D System Alternatives

The last few years have seen a proliferation of computer systems aimed at the CAD/D market. The selection process can be simplified by giving some prior consideration to fundamental questions regarding a candidate system's configuration.

3.2.1 Hardware

Consideration of the system hardware is directed by four main items: central processing unit (CPU) form, terminal types and configuration, peripheral requirements, and overall configuration (networking, protocals, etc.).

The question of the CPU form is broken down into two major divisions,

multipurpose mainframes serving CAD/D and non-CAD/D users, and dedicated systems for CAD/D. The latter option can utilize a mainframe, supermini, mini or a distributed CPU system. The CPU configuration is really dictated by what performance will be expected of the system. In turn, the system's performance will be governed by factors such as number of users, the task each user is performing, the interrelationship between users, and what aspects of the CPU resources are being utilized at any given time.

The current trend in CAD/D terminal types is away from the storage display tube technology and towards the high resolution color raster technology. From an operational standpoint the higher screen write rates, the ability to perform local pan and zoom functions, and the greater amounts of data that can be presented to the operator by virtue of having multiple colours justifies this trend.

Peripheral requirements will be dictated solely by the tasks a CAD/D system will be expected to complete. Hardware peripherals include such things as plotters, printers, hard copy units, tape drives and mass storage media. As an example, drafting requires large format pen plotters, printed circuit board (PCB) design requires photo plotters while configuration design requires only a hard copy device.

The overall design configuration is governed by the operational requirements. The number of workstations is partially governed by the locations, but is limited to the CPU and site restrictions. If the workstations are remote, then networking and protocol methods for communication must be considered.

3.2.2 Software

Software for CAD/D systems can be considered under three headings: system, application and programming software.

System software is the element that manages a system's operation and as such directly contributes to the system performance. System software becomes a non-variable item for CAD/D systems retrofitted to existing CPU's. Standalone systems usually have customized system software while the needs of the user community (not just CAD/D users alone) will dictate the system software for mainframes. Due to this fact, standalone systems typically have better performance ratings (based on response time) than do mainframe based systems.

User community requirements dictate the types of application software that is most appropriate. Certain elements in the realm of applications software are however, common to multiple user groups. This commonality typically encompasses such things as data base management, bill of materials and geometry creation and manipulation. Many CAD/D systems also provide special applications packages such as extended geometry, printed circuit board (PCB) design, finite element modelling (FEM), and numercially controlled (NC) machining. The extent of the involvement in acquiring special applications packages will necessarily be fixed by what a given organization hopes to achieve by implementing CAD/D.

Programming software is the element which allows an organization to enhance the existing system and application software. The major enhancement for a research organization would be in the creation of custom interfaces for existing applications. For multi-purpose CAD/D systems, the programming software must provide an easy method to customize the input/output methodology. This could be accomplished by the creation of macro routines or by the use of custom configured digitizers.

3.2.3 Maintenance

Maintenance on a CAD/D system can basically take two forms; the vendor is charged with the total system maintenance or the user can perform parts of the maintenance provided that the vendor supplies complete systems documentation. With the level of vendor customization taking place in current CAD/D systems, the former option is preferable.

3.2.4 Operational Methodology

Unquestionably the most important, the method of the integration of a CAD/D system into an established organization warrants serious consideration. Operationally speaking, an organization must establish what its product is, how it produces that product and how can CAD/D simplify, enhance or extend that production? Once it is established which working groups would benefit from CAD/D the process of selection and installation of an appropriate system is greatly simplified.

4. CAD/D AT DRES

Once CAD/D was considered to be of potential significant assistance to increasing the efficiency of the research and development taking place at DRES, a study directed at assessing the feasibility of installing CAD/D was initiated in December 1982. A copy of the terms of reference of the study is included as Appendix A.

The procedure used to accomplish the tasking was broken down into the following functions:

- provide familiarization of CAD/D through attendance at courses, exhibitions, establishments using CAD/D and vendors.
- evaluation of DRES requirements.
- market survey.
- submission of a request for quotation to select vendors.

4.1 CAD/D Familiarization

To understand the issues involved in considering a CAD/D system purchase, a course entitled "Practical CAD/CAM Considerations" was attended by the author. The intent of the course was to provide an understanding of all the elements that must be considered when evaluating CAD/D systems, starting at the initial feasibility study and proceeding right through to operator training on an installed system. The course was taught by Mr. S. Chasen and Mr. H. Schaeffer, each of whom has had more than a decade of experience in CAD/D technology.

Visits were made to two vendor sites: PDA Engineering and McAuto. PDA is not in the business of producing CAD/D systems, however a by-product of their involvement in state-of-the-art engineering was the generation of an FEM pre/post processor. This pre/post processor (named Patran-G) is a sophisticated input/output interface for various finite element packages. It is, however, limited to that function. McAuto produces a standalone CAD/D system called Unigraphics. This system can be configured so as to include all the required software and hardware and it can therefore be considered to be a turnkey system.

To provide a better understanding of the general market conditions, an equipment exhibition and conference (Graphics Interface '83) was attended. The

conference portion was composed of two days of tutorials and presentations by various vendors. In addition there were three days of state-of-the-art presentations by various organizations. Vendors were invited to establish demonstration booths which were open to the public for all five days. The Micro Electronics Centre, which was recently established at the University of Alberta, was visited. The system users provided a brief demonstration of their newly installed Computervision CAD/D system.

4.2 DRES Requirements

After having established a degree of familiarization with CAD/D technology, the formalization of DRES's CAD/D requirements was carried out.

4.2.1 User Community

The initial step was to establish the user community, which is composed of the various user groups, and determine where and how CAD/D could be used most effectively. Based on the replies to a general memorandum, user group representatives were selected and a general meeting was held. Representative of affected service groups were also in attendance. General discussion resulted in the identification of four main areas where CAD/D could be usefully applied. The requirements in these areas were discussed and the following summary of major requirements was compiled.

a) There is a requirement in electronic design at DRES to provide a more simplified means of generating printed circuit boards. PCB production at DRES usually consists of limited numbers of custom boards which due to the research nature of the work, typically undergo several modifications before the final product is obtained (see Fig. 1).

b) There is a requirement in mechanical design at DRES to provide a simplified means to design mechanical components. A typical example is DRES's involvement in the design of ROBOT-X, a subsonic aerial target. This target is composed of a mix of custom designed and off-the-shelf components. CAD/D would therefore not only aid in the design of custom components but also in the systems integration (see Fig. 2).

c) There is a requirement in finite element modelling at DRES to provide a means to input geometry and to visualize the results of existing finite element codes. Two programs (VAST and EPIC) are currently being used in the Military Engineering Section (MES) (see Fig. 3).

d) Finally there is a requirement to provide an automated drafting facility at DRES. CAD/D programs are particularly suited to satisfying this requirement. The time required to initially create a drawing is reduced, modifications to existing drawings are more easily accomplished and the archival functions are greatly simplified (see Fig. 4).

4.2.2 Computer Group

The system management of any CAD/D system purchased would be directed by the computer group. The major requirement of the computer group is that requests to provide custom development be kept to a minimum. This requirement is derived from the extensive involvement of the computer group staff in existing projects.

4.3 Market Survey

The next step was to begin a market survey to determine the number of existing systems that would satisfy DRES requirements.

4.3.1 Survey Rationale

Based on the first meetings and subsequent conversations with the individual user groups, the following conditions were placed upon the survey:

a) The CPU configuration was limited to the CPU's existing and available at DRES (Honeywell DPS8/70C or VAX 11/780) or to a standalone system.

b) As much as possible terminal and peripheral requirements should be satisfied by existing hardware at DRES.

c) If possible, all the user group requirements should be addressed by one generalized package.

d) Any package under consideration should have a convenient methodology to implement inter-CPU communications.

e) Modularity in order to allow future expansion is desirable.

A list of possible vendors was compiled from various sources, including the "Survey and Buyers Guide" compiled by Daratech Inc. [1]. The market survey was to be the source of a vendor list to be used in issuing a request for quotation (RFQ).

4.3.2 Survey Results

The market survey was finished on July 22, 1983 at which time an RFQ was issued. The survey indicated that there were fewer than a dozen systems that could satisfy DRES requirements. Subsequent conversations with the vendors, DRES staff, and outside agencies involved in CAD/D reduced the list of potential CAD/D sources to seven (six of which were standalone and one being a mainframe based software package).

4.4 Request for Quotation

4.4.1 RFQ Format

The intent of the RFQ was to provide information to DRES staff on the availability, relative merits and cost of CAD/D systems. The body of the request was broken down under the headings of minimum hardware, required software, optional software, and systems operations.

The required application software specifications addressed four package types: drafting, PCB design, mechanical design and bill of materials. Examination of DRES requirements and the areas in which CAD/D could most usefully be applied indicated that these four applications packages should initially be considered for immediate implementation.

The applications packages considered to be optional were an FEM pre/post processor, an airframe generation package, and a solids modeller. The pre/post processor was considered optional due to the fact that the FEM packages in use at DRES are considered to be non-standard, therefore standard interface packages are not available and therefore long-term computer group commitments are required to generate and support these interfaces. An airframe generation package does not per se, exist in any CAD/D system examined which in addition would support the general community requirements. All of the CAD/D systems examined have graphics languages which can be used to fulfill these requirements. The last optional

application package to be considered was a solids modeller. This package was included by virtue of the fact that it represents a state-of-the-art advancement in data representation methods. A full copy of the RFQ is attached in Appendix B.

4.4.2 RFQ Recipients

Based upon the market survey and discussions with CAD/D users and suppliers, the following list of prospective vendors was compiled:

a) Computervision Canada Inc.
b) Intergraph System Ltd.
c) Manufacturing Data Systems International-Canada Ltd.
(Marketing agents of the APPLICON CAD/D system)
d) Calma Co.
e) Auto-trol Technology Ltd.
f) McAuto (producers of Unigraphics).
g) Honeywell Ltd. (ANVIL 4000 marketing agents).

The RFQ was issued on July 22, 1983 and the responses were received from DSS in the last week of September 1983. Of the vendors that received the RFQ only McAuto declined to respond.

5. CANDIDATE SYSTEMS

In an effort to provide a better understanding of CAD/D systems, it was decided that some of hands-on experience for DRES staff would be beneficial. Since DRES recently purchased a Honeywell DPS8/70C mainframe and Honeywell Canada recently became involved in marketing a CAD/D system produced by Manufacturing and Consulting Services (MCS) called ANVIL, it was proposed that some staff familiarization would be beneficial. Subsequent consultations with Honeywell led to the installation of ANVIL at DRES for a period of six months, starting May 1983. The installation of ANVIL was made known to the user community and anyone wishing to use the system was given free access.

5.1 ANVIL-4000L

5.1.1 Package Overview

ANVIL 4000 is a large (approximately 400,000 lines of code) Fortran

based CAD/D system. Version 1.2 was initially installed at DRES on a demonstration basis. In August 1983 MCS announced the release of version 1.5. The program is menu driven and is primarily meant as a drafting and machining package. The entity display format is a wire frame representation and surfaces are handled by the boundary representation (B-rep) method. Built into the main package are a number of applications packages as follows:

- Schematics
- FEM mesh generation
- Bill of materials
- Data base management
- A graphics programming language.

The package is very flexable in terms of entity control, allowing for such features as variable curve fonts and manipulation of the entities (translation, rotation, mirroring, etc.). There are a large number of choices available when creating an entity and in addition the creation of complex objects is simplified by the true 3D capability and the availability of extended geometry functions (spline curves, multiple methods to create surfaces, and some solid primitives).

5.1.2 ANVIL Critique

The combination of ANVIL'S user friendliness and the tremendous potential to enhance the design process at DRES provides sufficient justification to consider it as the means to fulfill DRES's CAD/D requirements. There are however deficiencies in Version 1.2. Wire frame representations are poor when viewing complex 3 dimensional shapes since the object being viewed can be considered to be transparent. The standard method used to alleviate this problem is to incorporate a hidden line removal algorithm. This algorithm is currently not functional in Version 1.2. System documentation indicated that even if this algorithm was functional, it is not very sophisticated. Demonstrations of the more recent release (Version 1.5) have shown that a simpler means to satisfy this requirement has been provided. During the use of Version 1.2, minor software problems have been encountered but this is to be expected from any computer based system. The two major drawbacks of ANVIL are that it provides no component libraries in either the schematics or drafting functions, and,

possibly the most important, there is no facility to satisfy the PCB design requirements.

5.2 Standalone Systems

Barring minor differences, the systems information provided by the vendors in response to the RFQ indicates that these systems can be discussed on a generic rather than specific basis. This is justified if it is considered that a proper evaluation of standalone systems can only be performed when responses to a formal request for proposal (RFP) have been received.

The systems documentation received from the five vendors that responded to the RFQ indicated that any of the systems would be capable of satisfying all DRES requirements. This is based on the submitted documentation only and therefore does not include an operational evaluation. This evaluation would be done during the benchmark portion of an RFP.

5.3 Prices

The ANVIL 4000 software package price is approximately $150K (Canadian). This price does not include an applications package to perform PCB design. However Honeywell has indicated that they are currently in the process of negotiating a licensing agreement with Bell Northern Research (BNR) for the rights to market the latter's PCB design package. In addition, this price does not include hardware costs. Honeywell representatives have examined the facilities at DRES and have concluded that the mainframe computer and the existing terminals would support the operation of ANVIL. Some minor hardware acquisitions (small digitizer, hardcopy unit) would be desirable but not necessary.

The responses to the RFQ indicate that a complete standalone system sufficient to satisfy DRES requirements would cost in the range of $370K to $730K US.

The cost discrepency between ANVIL and the standalone systems arises from three factors:

- The standalone systems require the acquisition of a CPU.
- The standalone systems are delivered as a total system (turnkey) and have therefore undergone more extensive systems integration.
- ANVIL does not include some of the more costly application oriented functions (PCB design and FEM pre/post processing).

6. RECOMMENDED DRES POLICY

6.1 Justification

DRES is a research and development agency and as such the engineering work that typically takes place falls into three categories. The first category is that of customized, one-of-a-kind designs. As an example, the electronic design group at DRES produces fairly large numbers of custom designed PCB's. With the appropriate equipment, CAD/D systems can greatly simplify the design process right from board layout to photo quality masks. Current methods require that board specifications be issued to an external design agency for the final board design and assembly. A CAD/D system would therefore reduce both cost, and possibly more importantly, turnaround time.

The second category is that of the iterative design process used to provide a final design. As an example, the Systems Integration Group is using this design process to achieve a final design for ROBOT-X. The initial configuration of ROBOT-X was derived from an analytical aerodynamic analysis. Thereafter as systems and subsystems are added and/or modified the previous design must be altered. The impact of this type of design process is most noticable in the DRES drafting office where a single draftsman attempting to service many groups, must modify his existing ROBOT-X drawings or as more often occurs, create a new drawing. A CAD/D system would greatly augment the functional efficiency of the drafting office by virtue of its inherent ability to store and manipulate drawings.

The third category is that of applied research. This category is most evident in the Military Engineering Section (MES) where work is being done with finite element programming. Greater numbers of design alternatives could more easily be evaluated if the input requirements of FEM's could be satisfied by

using CAD/D. The creation of both the structure and mesh geometry would be simplified. Then by using an interface package this geometric data could be sent to the finite element program and after processing, the output of the program could be returned to the CAD/D system where the results could be viewed for evaluation purposes.

A cost benefit analysis was not undertaken as the economic return is not a major criterion in a research organization. The low end of the price scale ($150K) fits well within budgetary constraints, while the high end of the scale ($750K US), does not satisfy the budgetary constraints.

Due to the nature of the work occuring at DRES and the structure of the working levels, the manpower augmentation that would be provided by the implementation of a CAD/D system is sufficient justification to seriously consider the purchase of such a system.

6.2 System Recommendations

Implementation of ANVIL on a trial basis has brought about some interesting observations about CAD/D as it relates to DRES operations. The installation of ANVIL was undertaken to introduce CAD/D to an inexperienced environment in the hope of producing an awareness of CAD/D benefits. Initially the system did not see much use but the campaign to convince DRES personnel that CAD/D was useful slowly began to show results. Once a user has made the initial effort to learn the system's operations, experience has shown that the user will find increasing numbers of jobs that are simplified through the use of CAD/D. This initial reluctance to learn the system is probably due to two factors: the general lack of knowledge of what CAD/D is and what it can do for the designer and the fact that ANVIL was only installed on a demonstration basis and therefore potential users were less willing to commit time to a system that might not be available in the near future. There was a consensus among the people who had used ANVIL that a CAD/D system would be a justifiable expense.

At this time, the major criteria for the purchase of a CAD/D system is the minimization of the initial cost and DRES personnel committment required to install and maintain the system.

To summarize, for the following reasons the system recommended for purchase is ANVIL 4000L:

1) ANVIL operates (in a minimum configuration basis) on the hardware already in place at DRES.
2) Of the systems considered, ANVIL is the lowest initial cost (less than $150K Canadian).
3) Honeywell Canada can be charged with the maintenance of the package as an addition to the already existing maintenance contract.
4) Both Honeywell and MCS have shown a continuing committment to enhance the operation and widen the scope of ANVIL.

6.3 Future Planning

Accepting that ANVIL is to be purchased, consideration must be given to the implementation and operational requirements. The implementation requirements are minimal. Workspace is available for the terminals, communication lines to the computer are being established as part of building upgrades currently taking place, and based on the installation of Version 1.2 (which took two days), there should be no problem installing the system.

Of more concern is the training aspect. The drafting office has the greatest potential for increased productivity, however the work load of the single draftsman will not allow extended time slots to be allocated for training. To rectify this problem it is suggested that a term draftsman be employed for no less than three months thereby allowing the permanent draftsman to dedicate a block of time for training purposes. This need not interfere with the drafting operations since both draftsmen and the computer terminal can be placed in the same office.

The two major drawbacks of ANVIL, as previously discussed, are the lack of a PCB design package and the lack of standard libraries for the drafting and schematics applications. Since the PCB package can operationally be separate from the other elements, one avenue that will actively be pursued to satisfy DRES requirements in PCB design, will be the consideration of installing a standalone system entirely dedicated to PCB design. The ongoing marketing negotiations occurring between Honeywell and BNR will be monitored and in addition, the possibility exists that a PCB package that is independent of ANVIL could be

installed on a CPU already available at DRES. As an example, Digital Equipment Corporation markets a third party software package called Sci-Cards which could be installed on the VAX 11/780 already at DRES.

The problem of the lack of standard libraries can be resolved by one of three alternative solutions. Since ANVIL provides a relatively easy procedure to create the required elements in the library, either in-house time can be committed or an external contract could be generated to create the libraries. The third possibility is that other users of ANVIL have created the libraries that DRES would require and therefore negotiations could be undertaken to acquire these libraries.

7. SUMMARY

The potential benefits of installing a CAD/D system at DRES greatly offset the investment of time and money, that would be required. The Department of National Defence (DND) is considering CAD/D both to provide a design capability enhancement and as a design communication standard within the organization.

It is recommended that DRES management implement a CAD/D system at DRES in the form of ANVIL 4000L at a cost of $150K (1983).

ANVIL 4000L is the most effective system available for the resources authorized, primarily because it relies on the use of the existing mainframe computer. Alternatives would require the acquisition of a standalone computer which would raise the purchase price to the range of $370K to $750K.

A PCB capability does not currently exist within the ANVIL program, however, feasible alternatives to fulfill this requirement are being investigated.

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APPENDIX A

TASK DESCRIPTION

ANNEX A - TERMS OF REFERENCE:

SPECIAL ASSIGNMENT: SELECTION AND IMPLEMENTATION OF A LIMITED CAD CAPABILITY AT DRES

1. A) Carry out a study to determine the feasibility of acquiring a satisfactory Computer-Aided-Design capability for DRES under the constraints listed below;

   B) Recommend acquisition of a suitable system, if possible, or the best alternative, to DRES management;

   C) Acquire and implement any CAD system approved for purchase;

   D) Validate the system's satisfactory operation by verifying the wing attachment design of the ROBOT-X target.

2. GENERAL TECHNICAL REQUIREMENT

The system must be based upon existing software packages, compatible with existing DRES computer facilities, and capable of operation by engineering staff without CS support, ie. a "turnkey" system. It is desirable that it be applicable to structural, mechanical, and electronic design problems, with an output capability of engineering drawings and PCB masters.

3. MANAGEMENT/ADMINISTRATION

The study should address operation and management of the facility from such points of view as:

i) initial cost.

ii) recurring costs.

iii) software/hardware compatibility.

iv) expandability - both in terms of software and (remote) terminals.

v) training requirements.

vi) engineering versatility.

vii) software/hardware control.

viii) access to the system.

ix) etc.

4. FINANCIAL GUIDELINES

Total software and hardware costs in the first year should not exceed $150K. Future year costs will be a factor in the system selected.

5. COOPERATING STAFF

Mr. Penzes is expected to carry out the bulk of the study by himself. However, the essential/desirable requirements for such a system must be established by user groups, in particular by Messrs. Ollevier, Weiler, and Campbell (electronics design), Drs. R. Houlston and A. Markov and Messrs. C.G. Coffey and D. Beifus (mechanical/aeronautical design and drafting). Mr. N. Bannister of the computer group will provide advice on available programs and computer hardware/software compatibility.

6. VALIDATION DESIGN PROBLEM

Mr. Penzes will implement the system at DRES in cooperation with H/CG. He will validate it as a working system by completing a structural analysis of the proposed concept for the ROBOT-X wing attachment, including alternate designs if required.

7. SUPERVISION

Mr. Penzes will carry out this assignment under the direct supervision of H/SIG in Systems Section.

APPENDIX B

REQUEST FOR QUOTATION

1. REQUIREMENT

The Defence Research Establishment Suffield (DRES) is an R&D establishment operating within the Department of National Defence. The aim of the organization is to perform basic research into, and develop enhancement of, the operations of the Canadian Forces.

Work at DRES is divided into two divisions. The Defence Sciences Division performs R&D in the fields of chemistry and biology, while the Defence Technologies Division performs R&D in the fields of vehicle mobility, military engineering and military systems. In conjunction, DRES also maintains a drafting office, a machine shop, and an electronic design office.

In aid of enhancing the engineering and design functions at DRES, a study to determine the feasibiltiy of installing a CAD/CAM system has been initiated.

2. The intent of this document is to determine the prices of commercially available systems based upon the projected operating requirements at DRES. It is not intended that this document be construed to be a request for tender in any way. The contents are structured into three major sections. The first section is a preamble based upon DRES's current capabilities and hardware, the second section deals with the expected elements of a candidate CAD/CAM system, and the third section contains information on the format of return quotations. Return quotations should be based on, but not limited to, the expected system requirements.

3. DRES FACILITIES

Currently DRES's experience with CAD/CAM is limited to standard computer packages (for example PLOT-10). On location are VAX 11/780 and Honeywell DPS8/70C computers. Along with the standard alphanumeric terminals currently in use are assorted graphic terminals such as Tektronix 4113's and 4114's. In addition there are on location the standard peripherals (tape drives, plotters, disk packs etc.). The heaviest potential use of a CAD/CAM system would come from four user groups. They are; finite element modellers, mechanical design engineers, electronics design engineers and draftsmen.

4. SYSTEM SPECIFICATIONS

4.1 Hardware

It is anticipated that DRES requirements could be met with three workstations, two of which should be interchangeable from the operational viewpoint while the third would be used solely for drafting. The two main workstations should be in close proximity to the CPU. The two main workstations should incorporate high resolution (at least 1K x 1K) colour raster terminals. The drafting workstation should use a high resolution storage type display and should also be in close proximity to a drafting size plotter. Each workstation should have a zoom and par facility that allows the appropriate function to be generated in as short a time as possible (20 secs.)

4.2 Operating Software

The system should contain at least the following software elements; data base management, geometric modelling and a user accessible programming language. The data base management element should allow access (either directly or indirectly) to the computer storage of, and algorithms for generation of, various drawing components. It should also allow redefinition of drawing components (e.g. the system should allow a drawn part to be redefined as a pattern). This would simplify the task of replicating common elements. The geometric software element should allow easy generation of various elements (points, lines etc.) in a multitude of fashions. However, it is expected that from an operational standpoint, input requirements for various applications packages would be simplified by the customization of the input device, (e.g. the input operations required to generate a transistor in a PCB applications package and thread pattern in a mechanical applications package should be minimized. It is also necessary that all aspects of the software (operating, required and desired applications packages) be available at any time during the construction of a part.

4.3 Required Application Software

There are four required applications packages; drafting, PCB design, mechanical design and bill of materials. Of these four, only the PCB design package needs expansion as the other three are standard packages. The PCB package should have at least the following abilities:

- solid state and hybrid board design
- auto placement and routing to approximately 98%
- design of and multi-layer boards
- design of up to 12" x 12" boards
- photo quality plotting up to 4X magnification
- production of net lists.

The bill of materials package should be accessible from all the other applications packages. Standard libraries of components and basic analyses should exist in the appropriate applications (e.g. the ability to call up a bolt hole pattern and then analyze the effect on the moment of inertia is a basic requirement).

4.4 Optional Application Software

The three optional packages currently being considered are; an FEM pre/post processor, a solids modeller and an airframe geometry generation package. The pre/post processor should be able to generate both 2 and 3D meshes for any bounded arbitrary shape. The mesh types should be as flexible as possible. The post processor should allow simultaneous display of deformed and undeformed shapes.

The plot of the deformed shape should be flexible enough to allow the superpostiion of coded plots, i.e. the plotting of stresses from a minimum to a maximum level, contour plots of stress, the plotting of thermal gradients etc.

The solids modelling package should incorporate at least the following characteristics:

- the ability to combine solids by Boolean algebra
- surface presentation can be boundary representation with hidden lines removed or shaded surfaces
- a library of solids components and/or a variety of methods to generate the solids

The airframe geometry generation package is a specialized subset of mechanical design. As such it is expected that the requirements of generating airframes can in whole or in part be satisfied by an advanced mechanical design package. For part generation not directly available it is expected that a user friendly programming language would fulfill the remaining requirements. However a package dedicated to airframe geometry generation is the most attractive option.

4.5 Systems Operations

4.5.1 Communications

The physical layout is approximately as follows:

There are three sites of concern: Bldg 1, Bldg. 13 and EMS (Experimental Modelling Shop). Bldg 1 contains the Honeywell mainframe computer, Bldg 13 contains the majority of the engineering staff and would be the location of the two main workstations, and EMS contains the drafting office. In terms of distance;

- Bldg. 13 is approximately 100 meters from EMS
- Bldg. 1 is approximately 300 meters from EMS and 400 meters from Bldg. 13.

Baud rates should be at least 9600 between all workstations. Access to the offline storage medium (magnetic tape or removable diskpack) and the drafting plotter must be available from all the workstations. This access must be accomplished with a minimum amount of operator involvement. The critical component of the systems communications element is the ability to provide a geometric data file to the finite element programs currently installed on the Honeywell DPS8. The programs currently being used are non standard and it is therefore expected that the generation of the required interface will come from the adaptation of an existing interface. It is also possible that an translator could be generated if the CAD/CAM system follows the IGES

standard or if the system conforms to a neutral data file technique. Also residing in Bldg. 13 is a VAX 11/780 computer and the communication between the VAX and the CAD/CAM system is a desirable feature. Both the VAX and Honeywell computers are available on a limited basis to perform calculation intensive operations. An indication of the terminal response terminal response time degradation as a function of the number of users and the types of operations the CPU is executing is obligatory.

4.5.2 Systems Configuration

The system hardware configuration should be broken down into three parts; the CPU and it's peripherals, the workstations and the working environment. The minimum requirements and each possible upgrade in these three categories should be clearly itemized.

5.0 QUOTATIONS

The systems specifications in the previous sections are only intended to indicate DRES's minimum requirements. The intent of this document is to provide DRES with an understanding of the costing of CAD/CAM systems. After examining the quotations, consideration will be given to the issuance of a formal request for proposal.

Return quotations should be based on the development of the indicated application based CAD/CAM system from a minimum configuration. Quotes should be of the form of itemized lists beginning with the minimum software/hardware requirements (with their associated costs). The enhancement of the system should be based on the implementation of applications packages. Interspersed in the list should be the prioritized addition of software/hardware elements and their associated costs.

This quotation should be separate from any included software/hardware specifications. Performance data should also be included in the quotation. If software packages are to be released in the near future (less than one year) a definite date of that release is to be given. The maximum tolerance allowable on the issuing date is date of quote to the date of the package release plus three months.

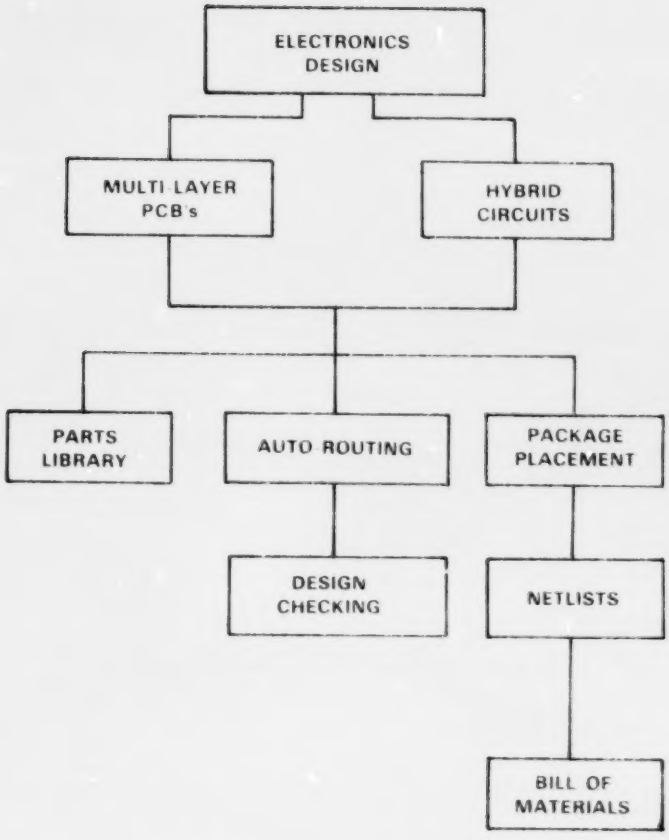

Figure 1

DRES ELECTRONIC DESIGN REQUIREMENTS

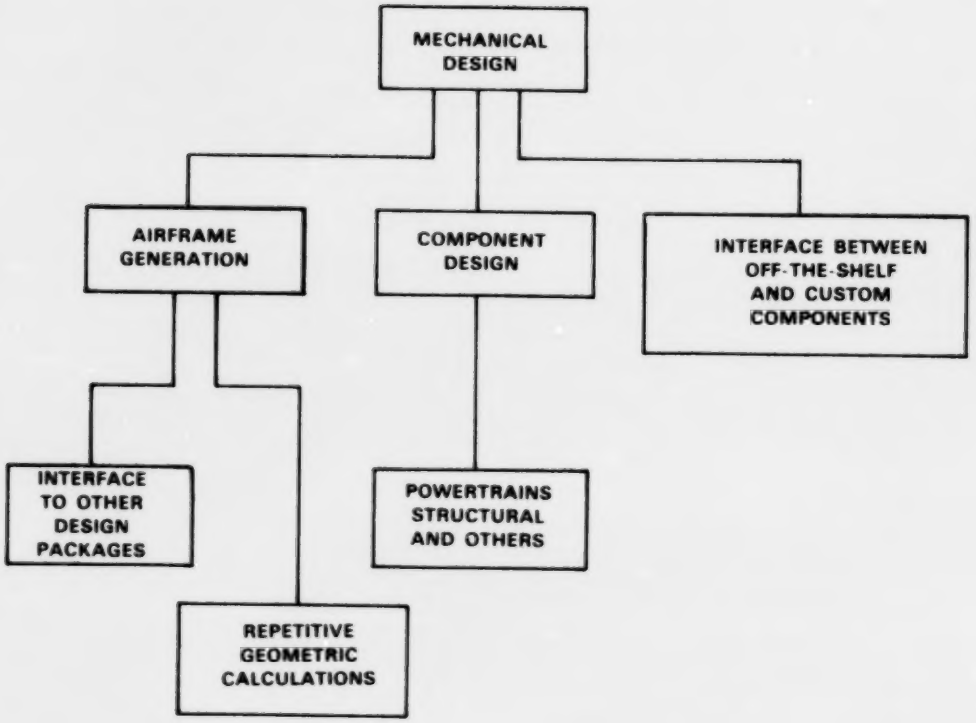

Figure 2

DRES MECHANICAL DESIGN REQUIREMENTS

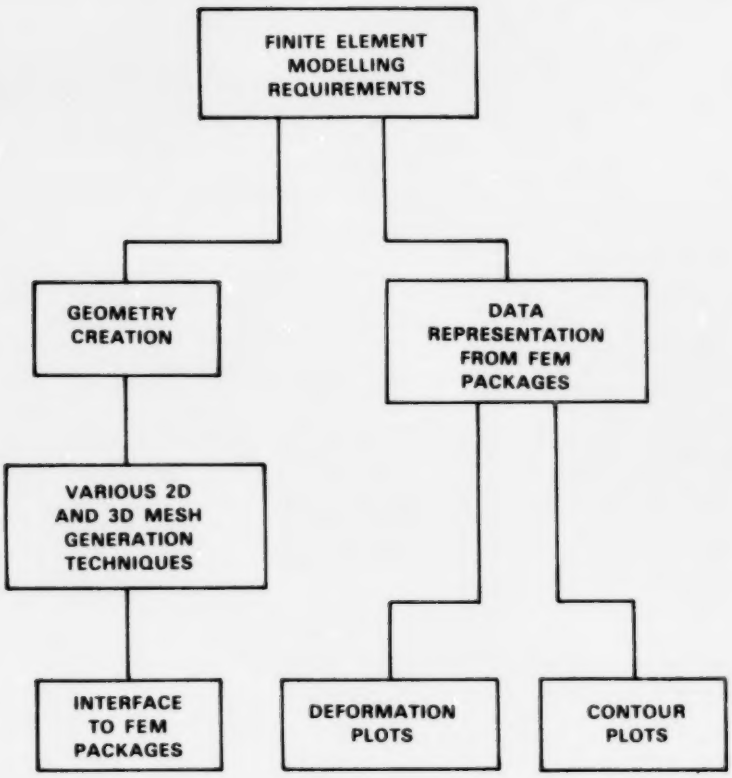

Figure 3

DRES FINITE ELEMENT MODELLING REQUIREMENTS

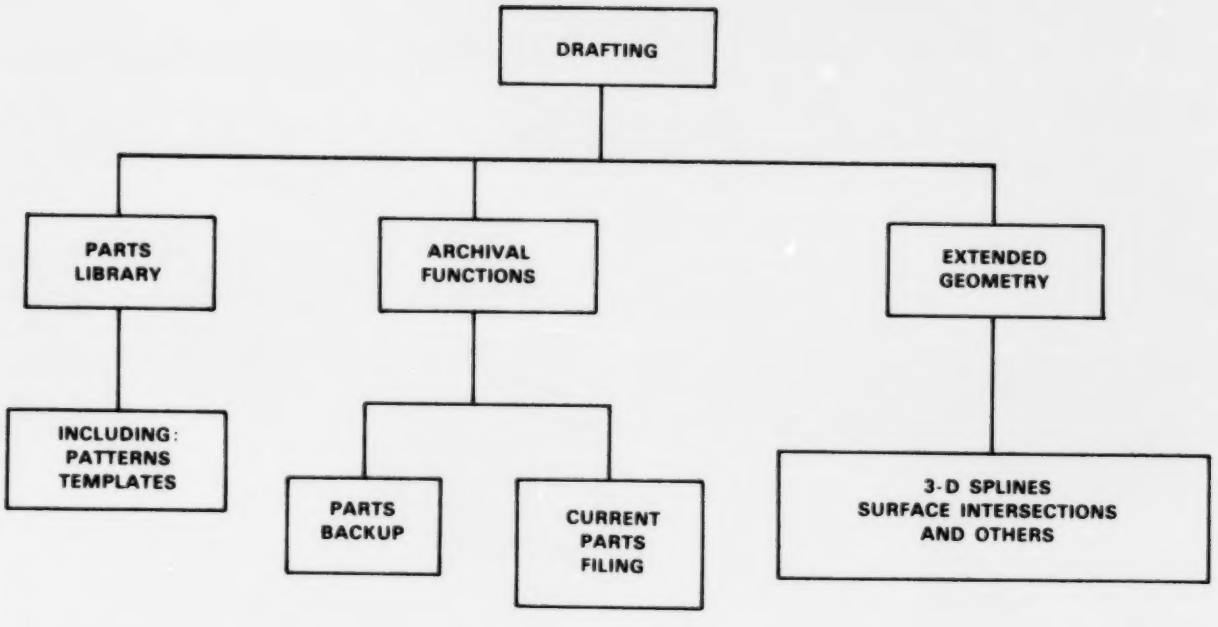

Figure 4

DRES DRAFTING REQUIREMENTS

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13. ABSTRACT

The feasibility of installing a CAD/D system at DRES is investigated with the constraints that the recommended system cost less than $150K (1982) and be a "turnkey" installation. The ANVIL 4000L software package, compatible with the recently acquired central computer, a Honeywell DPS8/70C, is recommended.

DSIS
79-678

KEY WORDS

ANVIL
CAD
CAD/D
Computer Aided Design
Computer Aided Drafting
Computer Aided Engineering
Computer Aided Research
Drafting
Graphics
Software

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